MEMORANDUM

TO: Allan Brouillet, Sue Kaelber-Matlock, and Brenda Brouillet (MDEQ)

FROM: Hector Galbraith (GES)

DATE: July 16, 2004

SUBJECT: GES comments on Entrix (2004) Wild Game Study Report

1. INTRODUCTION

As requested by Allan Brouillet of Michigan DEQ, I have reviewed the report: *Evaluation of PCDDs and PCDFs in Wild Game Taken From the Floodplain Along the Tittabawassee River* (Entrix, 2004). This study reports organochlorine contaminant concentrations in wildlife game species collected on Tittabawassee River floodplain in the winter of 2003/2004. These data were collected to support the evaluation of risks posed to human health by the contaminants polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs). However, the main objective of this review has been to evaluate the implications of the results in Entrix (2004) for the findings of two ecological risk assessments (ERA) already performed for the aquatic and terrestrial environments of the Tittabawassee River and its floodplain (GES 2003 and 2004, respectively), rather than to assess the utility of the results for any future human health risk assessment.

Specifically, this review focuses on two questions:

- To what extent do the data in Entrix (2004) support or refute the conclusions of the two previous ERAs?
- What are the limitations of these new data in evaluating ecological, rather than human health, risks?

Section 1.1 of this memorandum outlines some important background information regarding existing risk assessment results, and against which the results reported in Entrix (2004) should be viewed. Section 2 explores the extent to which these new results affect the conclusions of the two previous ERAs at the site. Section 3 identifies some limitations of the results in Entrix (2004) for evaluating ecological risk (as distinct from human health risk) at the site. Section 4 presents a concise summary of the results of this evaluation, and Section 5 lists the references cited.

1.1 Background

In 2003 and 2004 Galbraith Environmental Sciences (GES) performed two ERAs for the Michigan DEQ. The first of these (GES, 2003) focused on potential risks posed to piscivorous

(fish-eating) wildlife by organochlorine contaminants in sediments and fish in the Tittabawassee River. The second (GES, 2004) focused on evaluating risks posed to terrestrial wildlife by the same contaminants in the Tittabawassee River floodplain soils. The data on which the aquatic ERA was based included sediment contaminant concentrations collected by Michigan DEQ, fish contaminant concentrations also collected by DEQ, contaminant concentrations in bird eggs (wood duck and hooded merganser) collected by DEQ and U.S. Fish and Wildlife Service, and data from the scientific literature. The data on which the terrestrial ERA was based comprised soil contaminant concentrations collected from the floodplain by Michigan DEQ, and data from the scientific literature. Because the terrestrial ERA, unlike the aquatic, did not include extensive contaminant data from biota on the floodplain, but instead modeled these body burdens, it was considered to be a screening level assessment.

The main result of the aquatic ERA was that the PCDDs and PCDFs in the sediments and fish in the Tittabawassee River exposed piscivorous wildlife to unacceptable risks (PCBs were relatively minor contributors to this risk). This prediction was confirmed by the extremely high concentrations of contaminants in the merganser and wood duck eggs. Using a food chain modeling approach, the terrestrial ERA predicted that the exposure of floodplain avian and mammalian predators (including foxes and birds of prey) to PCDDs/PCDFs through their food chains would also result in unacceptable risks. At the time of writing of the terrestrial ERA, no data (apart from some chicken eggs) were available to confirm that terrestrial food chains were being contaminated by the contaminants known to be present in the soils. This, however, was one of the main predictions of the terrestrial ERA. It was recognized by GES and by Michigan DEQ that it was important to test this prediction by collecting and analyzing terrestrial biota from the floodplain.

2. IMPLICATIONS OF ENTRIX (2004) RESULTS FOR EXISTING TITTABAWASSEE RIVER AND FLOODPLAIN ERA

Entrix (2004) reports the results of the collection and contaminant analysis of white-tailed deer (*Odocoileus virginianus*), wild turkeys (*Melleagris gallopavo*), and fox squirrels (*Sciurus niger*) from the floodplain of the Tittabawassee River (upriver and downriver of Midland) during the winter of 2003/2004. All three species are members of terrestrial food chains, the white-tailed deer being a browser that feeds on terrestrial grasses, forbs, shrubs, and tree saplings (Chapman and Feldhamer, 1982); the wild turkey feeding mainly on fruits, nuts, vegetation, and some invertebrates (Eaton, 1992); and the fox squirrel feeding mainly on acorns and other fruits and nuts (Chapman and Feldhamer, 1982). Thus, the species collected by Entrix (2004) can be expected to be potentially exposed to contaminants through terrestrial food chains, rather than aquatic pathways.

In the laboratory, the deer, turkey, and squirrel samples were analyzed for PCDD, PCDF, and PCB congeners.

The results reported in Entrix (2004) have a number of important implications for both the aquatic and terrestrial ERA already performed for the Tittabawassee River and its floodplain (GES, 2003 and 2004):

- The results in Entrix (2004) clearly support the conclusions presented in GES (2003 and 2004) that the high concentrations of PCDDs and PCDFs in the soils and sediments originate in the vicinity of the City of Midland. Concentrations in deer, turkeys and squirrels at a reference site 9 km upriver of the Dow Dam were significantly lower than those at two sites (Smith's Crossing and near Imerman park) downriver of Midland. The results in Entrix (2004) also clearly show that the congener "fingerprint" of the dioxins and furans changes fundamentally at the City of Midland: upriver of this point, the TCDD-EQ of the congener mix is dominated by dioxins; downriver of Midland it becomes dominated mainly by the furans 2,3,4,7,8-PeCDF and 2,3,7,8-TCDF. This, again, indicates a local source in the City of Midland.

- The TCDD-EQ results also support the findings of the two ERAs that downriver of Midland PCBs are relatively minor contributors to the total dioxin-like toxicity in the biological samples, which is dominated by furans (particularly 2,3,4,7,8-PeCDF, and 2,3,7,8-TCDF).

- Most importantly, the results reported in Entrix (2004) clearly confirm the prediction in the GES terrestrial ERA (GES, 2004), that the dioxins and furans in the soils of the Tittabawassee River floodplain downriver of Midland are contaminating terrestrial foodchains: the concentrations of TCDD-EQ in the deer, turkeys and squirrels from downriver of the Dow Dam were up to two orders of magnitude higher than those above the dam. Since deer, squirrels and turkeys are likely to be eaten by predators, such as foxes or hawks, or by scavengers in the Tittabawassee River floodplain, this confirms that they also are exposed to dioxins and furans originating in the City of Midland.

3. LIMITATIONS OF THE ENTRIX (2004) RESULTS IN EVALUATING ECOLOGICAL RISK

As discussed above, the main results of Entrix (2004) confirm predictions from two earlier MDEQ ERAs (GES, 2003 and 2004). However, the Entrix (2004) organism collection and analysis was intended to provide data that could be used to evaluate risks posed by organochlorine contaminants to human health, rather than to ecological receptors. This emphasis on human health necessitated collection and analysis techniques and procedures that limit the utility with which the results can be fully extrapolated to ecological risk. Also, apart from these "intentional" limitations, at least one unintended limitation occurred. These limitations are discussed below:

- **The selection of study organisms leads to an underestimation of the exposure and risk to some terrestrial receptors**.

  Because of their lipophilic nature and resistance to metabolism and excretion, PCDDs and PCDFs tend to bioaccumulate up food chains, reaching their highest tissue concentrations in predatory organisms, especially those at the apices of longer foodchains. Thus, body burdens are typically higher in foxes or hawks than they are in the herbivorous or insectivorous organisms on which these species prey. Because of this effect, risks posed by PCDDs/PCDFs are typically highest in such top predators. Thus, focusing *only* on organisms lower in the food chains will result in an underestimate of the true risks posed by organochlorine contaminants to the food chain as a whole.

  Because of their potential consumption by humans, and the implications for risks to human health, the Entrix (2004) study sampled organisms that occupy relatively low positions in the terrestrial food chains: white-tailed deer are browsers and grazers that feed on above-ground vegetation. Similarly, wild turkeys and fox squirrels feed mainly on above-ground plant material (Section 2). Plants are known to accumulate PCDDs and PCDFs from soils relatively inefficiently, and translocate them from their roots to their above-ground parts with even lower efficiency (Fanneli *et al*., 1982; Reissinger *et al*., 1989). Therefore, the exposure of deer, squirrels, and turkeys will be much lower than that of their predators, or other organisms that occupy middle or higher positions on other trophic pathways, for example a soil – invertebrate – insectivore – predator pathway. Thus, by concentrating on herbivorous animals relatively low in the floodplain foodchains, the body residues measured by the Entrix (2004) study cannot be considered representative of the magnitudes of the residues or risks to which many of the other organisms that exist on the floodplain will be exposed.

- **The sampling and processing of the study organisms lead to an underestimation of the body burdens in prey species to which some terrestrial receptors may be exposed.**

  PCDDs and PCDFs are highly hydrophobic and lipophilic. Because of these characteristics they tend to partition in organisms' bodies into fat. Typically, high concentrations are found in subcutaneous fat, and in fat deposits associated with the intestinal tract. Also, high concentrations are typically found in the liver, which concentrates and attempts to break down toxic substances. Much lower concentrations are found in less fatty body components such as muscle (Braune and Norstrom, 1989; Van den Berg *et al*., 1994). When preparing wild game for the table, humans usually remove the body cavity organs (including the intestines and liver) and the skin with its subcutaneous fat deposits. In preparing their collected animals for laboratory analysis, Entrix removed materials less likely to be eaten by humans. Specifically, they removed and discarded the skin, guts and other major organisms of the deer and analyzed only the muscle and the liver; they analyzed only the muscle of the squirrels; they discarded the internal organs of the turkey and analyzed only the muscle and skin. These procedures resulted in the discarding of body parts that could be expected to be PCDD/PCDF storage sites (skin and subcutaneous materials and guts in deer; skin and subcutaneous materials,

livers and guts in squirrels; and livers and guts in turkeys).

Unlike humans, predators and scavengers eat all or most of their prey, including skin and internal organs. Consequently, the discarding of important body parts leads to an underestimation of the whole-body PCDD/PCDF concentrations in deer, squirrels, and turkeys in the Tittabawassee River down river of Midland and, therefore, the exposure and risks to their predators and scavengers. In summary, the body residues measured by the Entrix (2004) study cannot be considered representative of the magnitudes of the residues or risks to which floodplain predatory or scavenging animals will be exposed.

- **Wild turkey sample distributions.**

  The Entrix (2004) deer and squirrel data show that PCDD/PCDF body residues were lowest at the reference site upriver of Midland, significantly higher at Smith' s Crossing, and higher still at the sampling site near Imerman Park. Specifically, the deer muscle, deer liver and squirrel muscle concentrations were higher at the Imerman Park site than at Smith's Crossing by factors or 3.1, 5.8, and 3.3, respectively (these patterns mirror underlying patterns of sediment and soil concentrations [e.g., Hilsvcherova *et al*., 2003; MDEQ, 2003]). The turkey data set conforms to this pattern in that the body residues at Smith's Crossing were higher than at the reference site. However, only one turkey was obtained at the Imerman Park sampling site and the resulting data were lumped with the Smith's Crossing data. The mean skin-on turkey TCDD-EQ concentration for Smith's Crossing was 10.2 ng/kg. However, based on the deer and squirrel samples, it is likely that if sufficient numbers of turkeys had been obtained from Imerman Park, their body residues may have been higher by factors of 3-6. Thus, the Entrix (2004) turkey data can be reasonably assumed to underestimate the actual body burdens of turkeys in the lower floodplain (and, hence, the exposures and risks posed to their predators and scavengers).

4. SUMMARY AND CONCLUSIONS

Review of the Entrix (2004) report has shown that the data contained therein support one of the major conclusions of the Michigan DEQ terrestrial ecological risk assessment (GES, 2004), that is that biota and food chains on the Tittabawassee River downriver of Midland are contaminated by PCDDs and PCDFs. A reasonable conclusion from this is that predators and scavengers at the tops of these food chains are likely to be even more exposed to these contaminants than the deer, squirrels, and turkeys sampled in the Entrix (2004) study.

However, the Entrix (2004) study was designed to generate data for an evaluation of risk to human health, rather than to ecological receptors. Because of this, design elements in the Entrix (2004) study, though perhaps appropriate for a human health risk analysis, result in an underestimation of the contaminant concentrations to which wildlife would be exposed and, hence, the magnitude of the risks incurred. These design elements comprise:

- The sampling was confined to organisms which, because of their diets, are unlikely to bioaccumulate PCDDs and PCDFs to the extent that other organisms would.

- The carcass handling procedures resulted in a likely underestimation of the magnitudes of the PCDD/PCDF whole-body burdens to which predators and scavengers may be exposed.

- The sample spatial distribution almost certainly results in an underestimation of the PCDD/PCDF body burdens of turkeys in the lower sections of the floodplain, and, hence, in the potential exposures to their predators and scavengers.

5. REFERENCES

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